

Kentucky
Agricultural Experiment Station
University of Kentucky

**THE GRAPE LEAFHOPPERS OF BLUEGRASS
KENTUCKY**

BULLETIN NO. 254.
(Research Bulletin)



Lexington, Ky.

August, 1924

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BULLETIN NO. 254.

The Grape Leafhoppers of Bluegrass Kentucky

By H. H. JEWETT

The grape leafhoppers are sucking insects which secure their food both in the immature and adult stages by piercing the tissues of the leaf with their beaks and sucking up the cell sap. The injury caused by the piercing of the leaf and removal of the juices is first indicated by a yellowing or whitening in patches on the upper surface of the leaf and later, as feeding continues, by a yellowing and browning of the entire leaf. These brown leaves are functionless and drop off prematurely.

The hoppers begin their attacks on the first shoots that appear on the vines and especially on those near the ground or lower part of the trellis. The leaves on these first shoots, when the infestation is severe, turn brown and drop off early in the season. By midseason, the leaves on considerable areas of the vine become more or less injured. The injury to the leaves causes a lessening of the growth of the wood and decrease in the yield and quality of the fruit.

SPECIES AND VARIETIES OF GRAPE LEAFHOPPERS

A number of species and varieties of grape leafhoppers were found infesting grapevines on the Station farm during the seasons of 1920, 1921 and 1922. The most important of these are *Erythroneura comes*, the variety *oconotata*, and *Erythroneura vulnerata*. The variety *vitis* was present in considerable numbers in 1921 and 1922, and there were a few hoppers on the vines of the variety *ziezac*. *Erythroneura tricincta* was found only very occasionally, there being not more than a dozen among several thousand hoppers collected. For three seasons, collections of leafhoppers were made and the per cent of the different kinds is as follows:

1920 *E. comes* var. *comes* 49.5, var. *octonotata* 33.0, *E. vulnerata* 17.5
1921 *E. comes* var. *comes* 24.9, var. *octonotata* 60.3; var. *vitis* 3.3; *E. vulnerata* 11.5.
1922 *E. comes* var. *comes* 9.0, var. *octonotata* 60.0, var. *vitis* 7.5; var. *ziczac* 1.5; *E. vulnerata* 22.0.

LIFE HISTORY AND HABITS Overwintering Adults

Hibernation. The grape leafhoppers hibernate as adults under leaves or rubbish of various kinds near or within the vineyard. A woodlot or fence row offers convenient places for hibernation. *Erythroneura comes* and the varieties *octonotata*, *ziczac* and *vitis*, and *E. vulnerata* may all be found in one pile of rubbish or clump of grass. In the fall of the year, all these hoppers have been seen flying from the vines to the orchard or woodlot nearby.

Activities in Early Spring. *Erythroneura comes* and its varieties become active in the early spring and may be found on a number of different plants before migrating to the grapevines. *E. comes* var *comes* and the variety *octonotata* were found as early as March 29, 1921, on hollyhock plants. The hoppers were found on hollyhock, dock, plantain, clover, asparagus, rhubarb, strawberry, chickweed and dandelion. They seem to be able to live on a great variety of plants in the early spring. At the time they were leaving the spring plants for the grapevines, the hoppers were found on plum, cherry, lila^t and roses. The hoppers were first seen on grapes on April 29, 1921, and May 1, 1922. Within a week their numbers were greatly increased on the vines, and by May 16 in both seasons, they had practically all left their spring host plants. Nymphs appeared on the leaves as early as May 24 in 1922.

***Erythroneura Comes* Var. *Vitis*.** OVERWINTERING ADULTS

Copulation and Oviposition. This variety of *comes* was found copulating for the first time on May 16 in 1921 and 1922. No copulating pairs were found after May 27, 1921 and May 30, 1922. Hatching nymphs were found on May 24, 1922. By allowing ten days, or the minimum egg period, the eggs for these nymphs were laid May 14, which would give the time of copula-

tion a few days before that date. It is probable that matings took place from the first week of May thru about the first week of June, which would correspond with the mating period of the other varieties of grape leafhoppers. There were so few adults of *vitis* in the fields in early spring that it was difficult to get sufficient numbers for rearing. Overwintering adults in cages deposited eggs from May 25 to about July 15 in 1921. Hatching nymphs that season were found for the last time on July 28. Eggs were deposited by overwintering females in cages in 1922, from May 22-25 to about the first of August. These adults were collected May 16 and were transferred to new leaves May 22 and May 25 and the first eggs were laid some time between May 22 and May 25. The last nymphs from these adults hatched on August 10.

Longevity of Overwintering Adults. Overwintering adults of the variety *vitis* live on the vines till late in the season. On May 27, 1921, 14 adults were placed on grape leaves in order to see how long they would live. Twelve were alive June 17, 8 on July 4, 5 on July 28, 3 on August 11 and on August 25 all were dead. Eighteen adults were placed on grape leaves on May 30, 1922, and of these 16 were alive June 15, 10 alive July 7, 2 alive August 1, none alive August 22.

Number of Eggs Deposited. An estimate of the number of eggs deposited was obtained by confining adults on grape leaves and then counting the young produced. Two females which were seen to mate on May 16, 1921, produced 178 nymphs. The nymphs were collected as follows: 28 on June 17, 24 on June 25, 46 on July 4, 60 on July 20, and 20 on August 1. The females died some time between July 20 and August 1.

FIRST-BROOD ADULTS

Appearance and Maturity. First-brood adults began to appear June 18, 1921, but general emergence came about July 1. Adults appeared June 20, 1922, in cages, from eggs deposited by overwintering adults. From nymphs collected in the field May 24 to June 10, 1922, adults appeared June 15 to June 26. Adults commenced mating June 25 which indicated that early appearing adults were mature.

Copulation and Oviposition. Adults were mating freely the last of June both in 1921 and 1922. The exact limit of mat-

ing period was not determined but first-brood adults that appeared in cages as late as July 30, 1921, and August 1, 1922, mated and produced nymphs. Eggs were laid in 1921 from July 2 to about September 10. In the cage which enclosed first-brood adults, very young nymphs were found September 26 and there were still nearly mature nymphs on the leaves October 17. Second-brood eggs were hatching on July 15, 1922. These eggs were laid some time between June 30 and July 5.

SECOND-BROOD ADULTS

Appearance and Maturity. Second-brood adults began to appear on August 6, 1921, and August 1, 1922. In 1921, 13 females and 11 males which appeared August 6 to August 10 were placed in a bag on grape leaves and some of these mated and laid eggs the same season. Four males and 6 females of this lot were alive October 17. In 1922, 9 females and 10 males of the second brood which appeared August 1 and August 6 were placed in a bag and 7 males and 1 female were added on August 15. No eggs were deposited by the combined lot.

Oviposition. A few of the early second-blood adults laid eggs in 1921. In the bag in which the adults were kept, very young and hatching nymphs were found September 10 and nymphs continued to hatch until September 28. The oviposition period in the case of the adults must have begun during the last few days of August and lasted until about the middle of September.

STAGES OF THE INSECT

The Egg

Description and Appearance. The eggs of the variety *vitis* were about three-fourths of a millimeter in length by a third as wide. They are slightly curved and somewhat bean-shaped. The eggs are difficult to find because of the hairy surface of the leaf and because they are placed under the epidermis of the leaf. They appear as slightly raised places on the leaf and may be seen within the tissue by transmitted light. The eggs are very delicate and are difficult to separate from the tissues within which they are placed.

Location. The eggs of this leafhopper are laid beneath the epidermis on the underside of the grape leaf. There is no defi-

nite arrangement of the eggs. They may be found scattered over the general surface of the leaf between the veins, near or around the edge, or along the veins or under the epidermis of the veins.

Incubation Period. The incubation period was obtained by confining adults on grape leaves for periods of not over 24 hours and then recording the time when the nymphs hatched. By this method a reasonably true incubation period was obtained. This period for 43 complete rearings in 1921 averages about 13 days, with the shortest period 10 days and the longest 15 days.

The Nymph

Description. The nymph molts five times during its development, the adult appearing after the last molt. When it is just hatched from the egg, the nymph is very small and semi-transparent, with large red eyes and the head and thorax seen large in proportion to the abdomen. After the first molt, the body lengthens and becomes more cylindrical, and the red coloring of the eye partly disappears. During the second stage, faint indications of brown markings appear on the thorax and the wing pads begin to appear as lateral projections. After the second stage, the most conspicuous changes are the development of the wing pads and intensification of the coloring of the thorax. In the last stage, the entire dorsal surface of the thorax is brown except a clear median line, and about half the wing pads are brown or darkened anteriorly.

Nymphal Period. The nymphal period for 73 rearings made in 1921 and 1922 averages about 16.5 days. Of these 73 rearings, the shortest time necessary for a nymph to complete its development was 14 days and the longest 21 days.

Adult

Description. The head with the vertex yellow, sometimes marked with reddish lines or with the central part more or less reddish. Pronotum, red or bright red with anterior margin yellowish or pale-colored and sometimes with pale lines on the disk, and posterior margin pale; scutellum red. The base of the elytra is bright red, followed by a transverse yellowish or whitish bar more or less broken into spots, and back of this bar, a large, bright red semicircular mark covering the middle part of the

elytra from about the middle of the clavus to the black mark on the costal margin to the tip of the clavus. This central mark is often brown or dusky at the middle. A second transverse yellowish or whitish band surrounds the central red mark and extends just beyond the cross-vein. A bright red ramosc line covers the cross-veins and adjoining parts of the longitudinal veins. The apex of the elytra is smoky, with a black spot in the second apical cell. Length of male 2.87 mm., length of female 2.91 mm.

Development

Length of Life Cycles. Adults that appear late in the season live over winter and return to the grapevines early in May the following spring. A part of these adults may live on the vines until late summer, thus giving them a life cycle of about a year. The adults that appear from eggs laid in May and June or the greater part of June mature and lay eggs for a month or two and die. For these the life cycle may be three to four months. On July 22 to July 30, 1921, 20 females and 17 males of the first-brood which were reared from eggs that were laid June 28 to June 30, were placed in a bag on grape leaves. A part of these adults matured and produced nymphs the same season. There were alive October 15, 17 females and 7 males and of these 1 male was alive May 10, 1922. This male lived until June 16. In 1921, a part of the second-brood adults that appeared on August 6-10 matured and laid eggs for about three weeks. These adults had a life cycle of about two months.

Number of Generations. A partial third brood developed during the season of 1921, but this was not the case in the season of 1922, even tho the second-brood adults began to appear a few days earlier.

Copulating pairs of overwintering adults were found from May 16 to May 27 in 1921 and from May 16 to May 30 in 1922. Adults were not numerous in the field so that it was difficult to determine the limits of the mating periods. Hatching nymphs were collected in the field on May 24 in 1922, so for that season, at least, matings must have taken place a few days earlier than the earliest mating date indicated for that year.

First-brood adults began to appear June 18, 1921, and June 15, 1922, in cages. Mating pairs were found during the latter

part of June for these two seasons and adults that appeared as late as August 1 mated in cages in 1922.

Second-brood adults which appeared from August 6 to August 10 in 1921, at least matured in part, since hatching nymphs were found from September 10 to September 28 on leaves upon which members of this brood had been confined. No eggs were deposited in cages by second-brood adults in 1922.

RECORDS OF REARINGS. 1921

Table 1—First Brood—Var. *vitis*

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|--------------|--------------|--------------|--------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 13.11 | Days 3.41 | Days 2.35 | Days 2.81 | Days 3.11 | Days 4.64 | Days 16.41 | Days 29.58 | 9 | Males |
| Range | 10-15 | 3-5 | 1-3 | 2-3 | 2-4 | 3-6 | 15-18 | 27-32 | 8 | Females |

Table 2—Second Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|--------------|--------------|--------------|--------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 13.33 | Days 4.16 | Days 2.58 | Days 2.41 | Days 2.93 | Days 4.25 | Days 16.25 | Days 29.60 | 4 | Males |
| Range | 12-14 | 4-5 | 2-3 | 1-4 | 2-4 | 3-5 | 14-18 | 27-31 | 8 | Females |

Table 3—Third Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|--------------|--------------|-------------|--------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 12.85 | Days 3.42 | Days 2.78 | Days 3.0 | Days 3.28 | Days 4.78 | Days 17.21 | Days 30.07 | 6 | Males |
| Range | 12-14 | 3-5 | 2-4 | 2-4 | 3-4 | 4-7 | 15-21 | 27-34 | 8 | Females |

RECORDS OF REARING. 1922

Table 4—First Brood

| | Nymphal Instars | | | | | Nymphal Period | Number Reared | Sex |
|---------|-----------------|--------------|--------------|--------------|-------------|----------------|---------------|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | |
| Average | Days 3.18 | Days 2.63 | Days 2.54 | Days 3.19 | Days 4.0 | Days 15.45 | Days 6 | Males |
| Range | 3-4 | 2-3 | 2-3 | 3-4 | 3-5 | 15-16 | 5 | Females |

Table 5—Second Brood

| | Nymphal Instars | | | | | Nymphal Period | Number Reared | Sex |
|---------|-----------------|-------------|-------------|-------------|-------------|----------------|---------------|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | |
| Average | Days 3.4 | Days 2.7 | Days 3.1 | Days 3.5 | Days 4.5 | Days 17.2 | Days 10 | Males |
| Range | 2-4 | 2-4 | 2-4 | 3-4 | 3-5 | 17-18 | 9 | Females |

Explanations of Tables of Rearings

Table 1. The eggs for the rearings represented in this table were laid May 25 to May 28, by two overwintering females which were found copulating May 16. The adults appeared June 22 to June 29.

Table 2. The rearings represented in this table were made from eggs which were laid on July 10. The adults appeared August 6 to August 10.

Table 3. The rearings represented in this table were made from eggs deposited on August 28, September 1 and 2, by second-brood adults. The adults appeared September 27 to October 5.

Table 4. The rearings represented in this table were made from nymphs which hatched June 6 to June 11 in a cage which contained overwintering adults. The overwintering adults were collected and placed in the cage May 16. The reared adults appeared June 20 to June 27.

Table 5. These rearings were made from nymphs which hatched on July 15 and July 19 and July 20 in a bag which contained first-brood adults. These first-brood adults were obtained June 15 to June 20 from nymphs collected in vineyard on June 1 to June 10. The second-brood adults appeared August 1 to August 6.

Summary

The adults of the variety *vitis* hibernate during the winter months under leaves and trash and at about the first of May return to the grapevines. Here they mate and commence laying eggs at the middle of May or a little later and some of the adults live till late in the season and deposit eggs until about the middle of July.

First-brood adults begin to appear as early as June 15. Members of this brood lay eggs after the first few days of July to about the second week in September. Second-brood adults begin to appear about August 1. In the season of 1921, a very partial third brood developed, the first nymphs hatched September 10 and the last on September 28 in a bag containing second-brood adults.

The hoppers migrate from the vines to their winter hibernating quarters in October. Very few hoppers were found on the vines after October 10, 1921, and October 16, 1922.

Erythroneura Comes, Var. Comes.

OVERWINTERING ADULTS

Copulation and Oviposition. Copulating pairs of *Erythroneura comes* were found in the field as early as May 8 in 1921 and 1922, but there was not a great deal of mating until May 16, when the adults were plentiful on the vines. The greater number of matings took place from about the middle of May to the first of June.

The first eggs were laid on May 25 in the spring of 1921 and on May 20 in 1922, by adults confined in bags. Eggs were laid earlier than this in the vineyard, since hatching nymphs were found as early as May 24, 1922. Overwintering adults in 1921 deposited eggs until about September 15. This season hatching nymphs were found September 26 on leaves in a bag from which overwintering adults had been removed on September 15. During the season of 1922, the last nymphs from overwintering adults hatched on September 6. These nymphs appeared on leaves from which the overwintering adults had been removed on August 22.

Longevity of Overwintering Adults. A part of the overwintering adults may live on the grapevines the entire season.

On May 16, 1921, 53 adults were collected and confined on grape leaves in a cheesecloth bag and frequent changes to new leaves were made in order to prevent intermingling with newly transforming adults. The number of adults at the time of each transfer to new leaves is as follows: May 16, 53 alive; May 30, 47 alive, 3 escaped; June 17, 40 alive, 5 escaped; July 4, 30 alive; July 29, 17 alive; August 23, 12 alive, 2 escaped; September 9, 9 alive; September 15, 4 alive; September 26, 3 alive; October 14, 2 alive. The two adults that were alive on October 14 were placed in a cage, but they were not alive the following spring. During the season of 1922, overwintering adults were kept alive in bags until after September 6, the last adults dying some time between September 6 and September 18.

Number of Nymphs Produced. On May 25, 1921, four copulating pairs were placed in a bag on grape leaves in order to see how many nymphs would be produced by the females during the season. These adults were transferred to new leaves at sufficient intervals for preventing confusion that might arise from intermingling with newly transformed adults. The four females produced 323 nymphs which were collected from leaves as follows: 54 on June 20, 100 on July 4, 83 on July 15; 40 on July 29, 30 on August 23, 16 on September 16. Three females, in 1922, produced 277 nymphs. These females were taken May 20 while copulating with males and were placed together in a bag on grape leaves. The nymphs were collected from the leaves as follows: 70 on June 19, 41 on July 7, 66 on July 20, 38 on August 11, 42 on August 23, 10 on September 18. The average number produced by seven females is about 85.

FIRST-BROOD ADULTS

Appearance and Maturity. First-brood adults in 1920 were reared from nymphs collected in the vineyard and the first of these appeared on June 24. First-brood adults reared from eggs began to appear on June 22, 1921, and on June 20, 1922. However, first-brood adults reared from nymphs collected in the vineyard, began to appear on June 10, 1922. The adults began mating about 10 days after emergence.

Copulation and Oviposition. The earliest matings observed took place on June 20, 1922, but mating pairs were seen most

frequently after the first week of July to about August 1. Adults that appeared during the last week of July and the first few days of August mated and laid eggs the same season.

First-brood adults in bags commenced laying eggs on July 6 in the season of 1921 and continued to about September 10. Very young nymphs were found on September 26 on grape leaves from which the adults had been removed on September 10. No other nymphs appeared altho several adults were alive in a bag on October 14. First-brood adults commenced to lay eggs on June 24 in the season of 1922, and continued to September 1. This season, hatching nymphs were found on September 15 on leaves from which the adults had been removed on September 1, but no other nymphs appeared in the bags in which adults had been confined from September 1 to October 23.

Number of Nymphs Produced. The approximate number of eggs laid was determined by confining the females on grape leaves and then collecting the nymphs when they hatched. On June 24, 1922, ten copulating pairs were placed in a bag and were kept under observation thru the entire season. These adults produced 462 nymphs which were collected as follows: 79 on July 22, 146 on August 15, 160 on September 1, 52 on September 8, 25 on September 15. The average number produced by these females is about half that of the overwintering females.

SECOND-BROOD ADULTS

Appearance. Second-brood adults began to appear on July 31, 1921, and on July 19, 1922. During the two seasons, the earliest appearing second-brood adults matured and laid eggs for a period of about a month. Adults that appeared after August 7 did not mature and produce eggs that season.

Oviposition. During the season of 1921, 26 males and 22 females, which appeared from July 31 to August 2, were placed in a cheesecloth bag on grape leaves to see if they would lay eggs. These adults were transferred to new leaves every day from August 11 to August 25, and the first nymphs were found hatching August 26 from eggs deposited in the leaves on August 16. Eggs were deposited up to about the middle of September, but no nymphs appeared on leaves upon which adults had been confined after September 15. Nymphs about one-third grown were

found October 4 on leaves from which the adults had been removed on September 15.

The first of the second-brood adults appeared July 19, in 1922, and the first eggs were laid August 10. The adults continued to lay eggs to about the middle of September but no nymphs were found on leaves upon which the adults had been confined after September 18. Very young nymphs were found October 4 on leaves from which the adults had been removed September 18. The third-brood adults appeared from September 7 to October 23.

STAGES OF THE INSECT

The Egg

Description and Appearance. The eggs of this leafhopper are about three-fourths of a millimeter long by a third as wide and are slightly curved or bean-shaped. They are very delicate and are semi-transparent with a slight yellowish tinge. The eggs are located just beneath the epidermis of the leaf on the under side and appear as slight elevations in a bright light. They are difficult to find without a lens because of their small size and because of the matting of hairs on the under surface of the leaf of many varieties of grapes.

Location. The eggs are placed just under the epidermis on the under side of the leaves. There is no definite arrangement in the placing of the eggs, some being placed along the midrib or even in the petiole, or they may be scattered over the surface of the leaf.

Incubation period. The incubation periods of 106 eggs from which complete rearings were made averaged 11.58 days. The minimum period was nine and the maximum 15 days.

The Nymph

Description. The nymph or immature leafhopper molts five times during its development. When it hatches from the egg, it is very small and nearly white. During the first stage, which lasts from two to five days, the nymph has large, conspicuous red or brownish eyes and the head and thorax seem large in proportion to the abdomen. The nymph in this stage is rather awkward in its movements and seems to have considerable difficulty in getting about over the hairy surface of the leaf. After

the first molt and during the second stage, some of the red of the eyes disappears, the body becomes elongated, the first faint yellowish markings begin to appear on the thorax, and the wing pads start as small lateral buds. This stage also lasts from two to five days. During the third stage, the color markings on the thorax become more conspicuous and the wing pads develop until they reach the caudal margin of the first segment of the abdomen. The third stage lasts from one to five days. In the fourth stage, the wing pads reach the caudal margin of the second abdominal segment. This stage lasts from two to five days. In the fifth and final stage, there is a further lengthening of the wing pads until they reach to about the middle of the fourth abdominal segment. The fifth stage lasts from three to seven days. After the fifth molt the adult appears.

Total Nymphal Period. For 106 complete rearings, the shortest nymphal period was 15 days and the longest 21 days, with an average of 17.2 days.

Adult

Description. The body color of *E. comes* is pale yellowish. The head is marked with an inverted sanguineous u-shaped line which is connected with spots on the inner sides of the orbits, or these markings are more or less interrupted. The pronotum has a sanguineous line on each side and a y-shaped mark on the disk, and the scutellum is colored on the basal angles and at the tip of the apex in many of the specimens. The elytra are marked with sanguineous spots and lines; clavus with a band along the claval suture, expanded on the inner side and extending to the elytral suture at about the middle of the clavus; corium with an oblique band near the base; also a long, narrow, oblique line which expands between the claval suture and the costal black mark and extends posteriorly to the ramosc markings of the cross-veins. There is an oblique dark mark across the posterior part of the costal plaque and dark spots on the base of the fourth apical and apex of the second apical cells. The color markings vary considerably both in intensity and extent. Length of male 2.69 mm., of female 2.7 mm.

Development

Length of Life Cycles. Hoppers that appear late in the season or after the first few days of August live over winter and return to the grapevines in the spring. These adults mate in the spring and lay eggs for two months or longer and then die. Many of the overwintering adults live till midseason or later and for these the life cycle is about one year. Such adults as develop from eggs laid in May and June, or a few days later, mature and deposit eggs for a month longer and then die. Included among these are the earliest appearing second-brood adults. These adults have a life cycle of three or four months.

Number of Generations. A partial third-brood developed during the seasons of 1921 and 1922. First-brood adults began to appear on June 24, 1920, on June 22, 1921 and on June 10, 1922. Second-brood adults were not secured until August 18, 1920, and these did not mate that year. In 1921, second-brood adults began to appear on July 31, and in 1922, second-brood adults began to appear as early as July 19. Second-brood adults in bags commenced to deposit eggs on August 16, 1921, and on August 10, 1922.

First-brood adults secured after August 5 in 1921, and after August 11, 1922, did not mate either season. On August 6, 1921, 41 females and 30 males were placed in a bag on grape leaves, but no nymphs were produced, and on August 11, 1922, 32 females and 38 males, which were placed in a bag, failed to produce nymphs. This leaves a considerable number of adults of this brood that do not mate and as a result the second-brood is not full-brooded.

A partial third brood developed during the seasons of 1921 and 1922; at least a part of early appearing second-brood adults may mature and lay eggs that season. In 1921, 26 males and 22 females of the second brood, which appeared from July 31 to August 2, were placed in a cheesecloth bag and eggs for a third brood were secured on August 16. Two males of this lot were alive on October 14. In 1922, eggs were secured from second-brood adults that appeared from July 19 to August 7, but none from this brood that appeared after August 7. Seventy-five females and forty males of this brood which appeared August 8 to August 11 did not produce nymphs that season.

Summary

The hoppers begin their fall migration from the vines to their winter quarters during the first week of October, and by the middle of the month, or a few days later, most of them have left the vines. The adults that survive the winter return to the grapevines in the spring as soon as the leaves unfold and begin depositing eggs about the middle of May.

During the season of 1921 and 1922, when special attention was given to the rearing of broods, a partial third brood developed. Adults that appear after the first week in August, or near that time, do not mate that season. This is the case with both first and second-brood adults.

TABLES OF REARINGS

Table 12—Second Brood. 1920—E. comes

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------|-----------------|-----------|-----------|-----------|-----------|----------------|-------------------------------|---------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 13.85 | Days 3.35 | Days 3.05 | Days 2.95 | Days 3.00 | Days 5.2 | Days 17.55 | Days 31.40 | 8 | Males |
| Range | 13-15 | 3-5 | 2-4 | 2-4 | 2-4 | 4-7 | 15-21 | 29-35 | 12 | Females |

Table 13—First Brood. 1921

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------|-----------------|----------|----------|-----------|----------|----------------|-------------------------------|---------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 11.85 | Days 3.7 | Days 3.1 | Days 2.25 | Days 2.9 | Days 4.45 | Days 16.50 | Days 28.35 | 11 | Males |
| Range | 11-12 | 3-4 | 2-4 | 1-3 | 2-4 | 4-5 | 15-18 | 27-30 | 9 | Females |

Table 14—Second Brood. 1921

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex |
|--------------------------|-----------------|-----------|-----------|-----------|-----------|----------------|-------------------------------|---------------|-----------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | |
| Average | Days 10.5 | Days 3.44 | Days 2.94 | Days 2.55 | Days 2.77 | Days 4.38 | Days 16.16 | Days 16.36 | 12 Males |
| Range | 10-11 | 3-4 | 2-5 | 2-4 | 2-4 | 4-5 | 15-17 | 25-28 | 6 Females |

Table 15—Third Brood. 1921

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex |
|--------------------------|-----------------|-----------|-----------|-----------|-----------|----------------|-------------------------------|---------------|------------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | |
| Average | Days 11.7 | Days 3.65 | Days 3.05 | Days 2.85 | Days 3.55 | Days 5.1 | Days 18.20 | Days 29.90 | 9 Males |
| Range | 10-15 | 3-5 | 2-4 | 2-4 | 2-5 | 4-6 | 16-21 | 27-33 | 11 Females |

Table 16—Second Brood. 1922

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex |
|--------------------------|-----------------|-----------|-----------|-----------|-----------|----------------|-------------------------------|---------------|-----------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | |
| Average | Days 10.26 | Days 3.33 | Days 2.93 | Days 3.26 | Days 3.00 | Days 4.66 | Days 17.13 | Days 27.40 | 7 Males |
| Range | 9-11 | 3-4 | 2-4 | 2-5 | 2-4 | 3-6 | 15-20 | 24-31 | 8 Females |

Table 17—Third Brood. 1922

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex |
|--------------------------|-----------------|-----------|-----------|-----------|-----------|----------------|-------------------------------|---------------|-----------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | |
| Average | Days 10.33 | Days 2.81 | Days 2.92 | Days 2.23 | Days 3.46 | Days 5.15 | Days 17.69 | Days 28.29 | 6 Males |
| Range | 9-12 | 2-3 | 2-3 | 3-4 | 2-4 | 4-6 | 16-20 | 27-29 | 7 Females |

TABLES OF REARINGS

Table 12. The rearings represented by this table were made from eggs deposited July 19 to July 25 by first-brood adults. The first-brood adults were reared from nymphs collected in the vineyard. These second-brood adults, as represented by the rearings in the table, appeared from August 21 to August 28.

Table 13. The rearings represented by this table were made from eggs deposited on May 25 and 26 by overwintering adults. The first-brood adults appeared June 22 to June 24.

Table 14. The rearings represented by this table were from eggs deposited July 6 by first-brood adults. The adults from these rearings appeared July 25 to August 3.

Table 15. The rearings represented by this table were made from eggs deposited August 16 to August 20. The adults from these rearings appeared September 15 to September 21 and are members of the third brood.

Table 16. The eggs for the rearings represented by this table were deposited June 24 to June 26, by first-brood adults which were reared from nymphs collected in the vineyard. The adults from these rearings appeared July 19 to July 25.

Table 17. The rearings represented by this table were made from eggs deposited August 10 to August 13. The adults from the rearings appeared September 7 to September 13 and are members of the third brood.

Erythroneura Comes Var. *Octonotata*.

OVERWINTERING ADULTS

Copulation and Oviposition. The first copulating pairs were found in the field May 8, 1921 and May 7, 1922. The mating period lasted for about three weeks these two seasons. Eggs were laid in 1921 from May 16 to about September 1, by adults confined in bags. The nymphs hatched as late as September 13. In 1922, the first eggs were laid, by adults in confinement, on May 25 and the last nymphs hatched September 1. Nymphs were found hatching in the vineyard as early as May 24 in 1922.

Number of Eggs Laid. Since the eggs are placed within the tissues of the leaf and are difficult to locate, the number of eggs laid by the females was estimated by counting the number of nymphs that appeared on the leaves. Four females that mated on May 17, 1921, produced 319 nymphs during the season.

These nymphs were collected from the leaves as follows: 34 on June 15, 150 on July 1, 60 on July 17, 40 on July 27, 25 on August 12, and 10 on September 1. Three females that mated

on May 24, 1922, produced 185 nymphs during the season, the last nymphs hatching on August 12.

Longevity of Overwintering Adults. Adults of the variety *oconotata* may live on grapevines until late in the season, or for a period differing slightly, if any, from that of the other grape leafhoppers. In 1921, the last of the adults confined in cheesecloth bags died some time between September 1 and 10, and in 1922, the last adults died during the last week of August.

FIRST-BROOD ADULTS

Appearance and Maturity. Adults of this brood began to appear June 20, 1920, June 14, 1921 and June 12, 1922, in cheesecloth bags and cages. The earliest matings were observed June 23, 1922, but by July 1, for three seasons, mating pairs were rather numerous, which indicated that some of the adults had matured.

Copulation and Oviposition. The mating period for this brood began the last week of June and extended thru the first few days of August. First-brood adults that appeared on July 15 to July 18 in 1921, mated and produced nymphs, but first-brood adults that appeared August 2 did not produce nymphs that season. Twenty-five adults were used in the first experiment and 40 adults in the second experiment. In 1922, 38 males and 49 females of the first brood, which appeared July 27 to July 28, were placed in a bag on grape leaves and a part, at least, of these matured and laid eggs that season.

First-brood adults commenced to deposit eggs on July 10 in 1920. These adults were not carried thru the season, but there were a few nearly mature nymphs on the vines in the vineyard as late as October 22. In 1921, the first eggs were deposited June 29 by first-brood adults, and there were newly hatched nymphs on the leaves on September 27. First-brood adults commenced to deposit eggs on July 3, 1922, and there were very young nymphs on the leaves October 4. These nymphs appeared in a bag from which first-brood adults had been removed September 14.

Number of Nymphs Produced. In order to find out how many nymphs were produced by first-brood adults, 10 females and 15 males, which appeared on June 20, 1921, were placed in a bag on grape leaves and were kept under observation until

the end of the season. These adults were transferred to fresh leaves at intervals in order to prevent possible intermingling with newly emerged adults. Nymphs were collected as follows: 51 on July 18, 240 on August 1, 208 on August 13, 146 on August 25, 26 on September 9, and 50 on September 29, there being 721 in all. One male and one female were alive on October 23, but they did not live thru the winter in a cage in which they had been placed.

SECOND-BROOD ADULTS

Appearance and Oviposition. Of the second-brood adults in 1920, the first appeared on August 9. Ten males and 12 females, which appeared from August 9 to August 17, were placed in a bag on grape leaves, but no nymphs were found up to the time the leaves fell off, about the first of November. Second-brood adults began to appear on July 25 during the season of 1921. Of this brood, 18 males and 26 females were placed in a bag on grape leaves on July 25 and July 26. Eggs were found August 10 and the nymphs commenced to hatch on August 22. Very young nymphs were found September 27 on leaves from which the adults had been removed on September 14. No other nymphs were found on the leaves upon which the adults had been confined from September 14 to October 17. The oviposition period for second-brood adults in 1921 lasted from August 10 to about the middle of September.

The earliest second-brood adults appeared on July 29 in the season of 1922. Members of this brood that appeared from July 29 to August 4 were placed in a bag on grape leaves to see if they would deposit eggs, there being 22 males and 20 females in the lot. Some of these at least matured and deposited eggs. The eggs were deposited from August 18 to about the middle of September. Very young Nymphs were found October 4 on leaves from which the adults had been removed on September 18, but no nymphs appeared on leaves upon which the adults had been confined from September 18 to October 22.

STAGES OF THE INSECT

The Egg

Appearance. The egg of the variety *oconotata* is about .75 mm. long by .25 mm. wide and is somewhat bean-shaped. In

general appearance and size it is identical with the egg of *E. comes*. It is placed under the epidermis of the leaf in similar locations as that of *E. comes*.

Incubation Period. The incubation period of 111 eggs from which complete rearings were made, averaged nearly 12 days. The shortest incubation period was 10 days and the longest 15 days.

The Nymph

Description. The young nymph upon hatching from the egg is a very small, semi-transparent, whitish creature with large red eyes and with the head and thorax rather large in proportion to the abdomen. The nymph molts five times, the adult appearing at the last molt. The most conspicuous change accompanying the molts of the nymph, is the development of the wing pads. These start as small projections or buds during the second stage and reach to about the second abdominal segment during the last stage. Such color markings as are present in the nymph, begin as very faint marks during the second stage and at the final stage a considerable portion of the mesothorax and the basal portions of the wing pads are black or dusky colored. The bristles, on the dorsal side of the abdomen, in the final stage, are arranged in two rows, one on each side.

Duration of Nymphal Period. The nymphal period, for 111 complete rearings made during the seasons of 1920 to 1922, averaged a little less than 17.5 days. The shortest time necessary for a nymph to complete its development was 14 days and the longest 21 days.

Adult

Description. The vertex and pronotum of the variety *octonotata* are marked as in the typical variety with the sanguineous markings rather obscure. The scutellum is marked in the center with a rather definite rectangular-shaped black spot. The elytra whitish, subhyaline, with pale, sanguineous marks at the base, fading to yellow toward the apex; apex smoky. There are four black spots on the elytra as follows: A transverse spot on the costal margin, a spot on the apex of the second apical cell, one at the base of the fourth apical cell and a large spot on the inner margin near the base. The upper surface of the abdomen is

dusky or black, especially on the basal segments. There is considerable variation in the intensity of color markings, some specimens being more highly colored than others. Length of male 2.74 mm., of female 2.73 mm.

Development

Length of Life Cycles. Adults that appear late in the season hibernate during the winter and return to the vines in the spring. Some of these adults may live on the vines until after midseason and for these the life cycle is about one year. The adults that develop from eggs laid in May and June have a life cycle of three or four months. Some of the second-brood adults that appear during the last few days of July and during the first few days of August may mature and, after depositing eggs for about a month, die. For these the life cycle is only about three months.

Number of Generations. During the season of 1920 no third brood developed. First-brood adults began to appear June 20 from nymphs collected in the vineyard, and the first eggs for a second brood were deposited July 10. Adults of the second-brood began to appear August 9. The first-brood adults were not followed thru to the end of the season, so no record was kept of the entire oviposition period. A partial third brood developed in the seasons of 1921 and 1922. First-brood adults began to appear on June 14 and second-brood adults on July 25 in 1921. Second-brood adults commenced to deposit eggs on August 10 for a third brood in 1921. First-brood adults began to appear June 12 and second-brood adults on July 29 in 1922. Second-brood adults commenced to deposit eggs for a third brood on August 18, 1922.

First-brood adults that appear after the first few days of August do not mature and produce nymphs the same season. This leaves a considerable proportion of first-brood adults that do not mature and produce nymphs the same season, so that a full second-brood is not produced.

RECORD OF REARINGS. 1920

Table 6—Second Brood. 1920—Var. Octonotata

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|--------------|--------------|--------------|--------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 13.27 | Days 4.04 | Days 2.86 | Days 3.04 | Days 3.45 | Days 5.22 | Days 18.63 | Days 31.90 | 10 | Males |
| Range | 12-15 | 3-7 | 2-5 | 2-4 | 3-5 | 3-7 | 17-21 | 29-35 | 12 | Females |

RECORD OF REARINGS. 1921

Table 7—First-Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|--------------|--------------|--------------|--------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 11.95 | Days 3.91 | Days 2.54 | Days 3.08 | Days 2.79 | Days 3.90 | Days 16.25 | Days 28.20 | 9 | Males |
| Range | 11-14 | 3-5 | 2-5 | 2-5 | 2-4 | 3-5 | 14-18 | 25-30 | 15 | Females |

Table 8—Second Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|--------------|--------------|--------------|--------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 10.41 | Days 4.05 | Days 2.47 | Days 2.35 | Days 3.17 | Days 4.11 | Days 16.17 | Days 26.59 | 8 | Males |
| Range | 10-11 | 3-5 | 2-3 | 1-3 | 2-4 | 3-5 | 15-18 | 25-28 | 9 | Females |

Table 9—Third Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex |
|--------------------------|-----------------|-----------|-----------|-----------|-----------|----------------|-------------------------------|---------------|------------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | |
| Average | Days 12.36 | Days 3.44 | Days 2.72 | Days 3.11 | Days 3.22 | Days 4.66 | Days 17.22 | Days 29.61 | 8 Males |
| Range | 11-13 | 2-5 | 2-4 | 2-4 | 2-5 | 4-5 | 16-19 | 28-32 | 10 Females |

RECORD OF REARINGS. 1922

Table 10—Second Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex |
|--------------------------|-----------------|-----------|-----------|-----------|-----------|----------------|-------------------------------|---------------|-----------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | |
| Average | Days 11.06 | Days 3.68 | Days 3.25 | Days 2.68 | Days 3.06 | Days 4.70 | Days 17.37 | Days 28.43 | 10 Males |
| Range | 10-12 | 2-5 | 2-4 | 2-3 | 3-4 | 4-6 | 15-20 | 26-32 | 6 Females |

Table 11—Third Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex |
|--------------------------|-----------------|-----------|-----------|-----------|-----------|----------------|-------------------------------|---------------|-----------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | |
| Average | Days 12.78 | Days 3.64 | Days 3.07 | Days 3.00 | Days 3.35 | Days 5.0 | Days 18.07 | Days 30.92 | 6 Males |
| Range | 11-15 | 3-5 | 2-4 | 2-4 | 3-4 | 4-6 | 16-21 | 28-35 | 8 Females |

Table 6. The rearings represented by this table were made from eggs deposited July 10 to July 18 by first-brood adults which appeared June 20 to June 25 from nymphs collected in the vineyard June 15. The second-brood adults represented in these rearings appeared August 9 to August 17.

Table 7. The rearings represented by this table were made from eggs which were deposited May 16 to May 18 and on May 26, by over-wintering adults. The first of these reared adults appeared June 14 and the last June 24.

Table 8. These rearings were from eggs deposited June 29, by first-brood adults. The adults from these rearings appeared July 25 to July 27.

Table 9. The rearings represented by this table were made from eggs deposited August 10 to August 12 by second-brood adults. The third-brood adults appeared September 7 to September 9.

Table 10. The rearings represented by this table were made from eggs deposited July 3 and July 4 by first-brood adults which appeared June 14 to June 19 from nymphs collected in the vineyard June 1 to June 10. These second-brood adults appeared July 29 to August 5.

Table 11. The rearings represented by this table were made from eggs deposited August 18 and August 19 by second-brood adults, the third-brood adults appearing September 16 to September 23.

Summary

The variety *octonotata* is one of the most important grape leafhoppers in Kentucky. It constituted about 30 per cent of all the hoppers on the vines in 1920 and 60 per cent in 1921 and 1922. The life history of this variety is practically identical with that of *Erythroneura comes*. The overwintering adults begin to migrate to the vines about May 1, and some of them may live until late in the season. These adults deposit eggs up to the first of September or a week or two later. First-brood adults begin to appear about the middle of June or a few days earlier and second-brood adults begin to appear during the last week of July or a little later. First-brood adults that appear after the first few days of August do not mature and deposit eggs that season. Second-brood adults that appear during the last week of July and the first week of August may mature and deposit eggs for a third brood. This was the case in the seasons of 1921 and 1922, but the third brood was only a very partial third brood. In order to secure a third brood, the earliest appearing first and second-brood adults must be selected for the rearings. Three seasons' rearings of *octonotata* showed that the second brood was not full brooded.

The fall migration to winter quarters takes place in October. During the first week, a few adults may be seen flying or drifting thru the air, and by the middle of the month, most of them have left the vines.

Erythroneura Vulnerata.

LIFE HISTORY AND HABITS

Economic Importance. *Erythroneura vulnerata* is a leafhopper of considerable importance as a pest of grapevines, and during the seasons of 1920 to 1922 constituted a considerable per cent of all the leafhoppers on the vines. In 1920, 17.5 per cent of the leafhoppers on the vines were *E. vulnerata*, in 1921, 11.5 per cent and in 1922, 22 per cent. This leafhopper was found on all the varieties of grapes in the Experiment Station vineyard, but was more numerous on the following varieties: Columbian, Concord, Herbemont, Isabella, Prentiss, Mericadel, Janesville, Regal, Rommell, Diano, Fawn and Lucile.

OVERWINTERING ADULTS

Hibernation. The adults of this leafhopper hibernate in leaves or accumulations of trash within the vineyard or nearby, wherever there is sufficient material for protection. This species was very easily found under leaves in a woodlot near the vineyard on the Station farm.

Activities of Adults in Early Spring. During the warm days of late winter and early spring, the adults become active and feed upon plants near their hibernating quarters. Before migrating to the grapevines, adults were found feeding most frequently on hollyhocks, dock, plantain, clover, chickweed, wild strawberry and rhubarb. When the leaves on the grapevines have expanded a few inches the hoppers migrate to the vines. Hoppers were found on grape leaves on April 29 in 1921 and on May 1, 1922. The first hoppers were found both seasons on leaves near the ground. By the middle of May the hoppers had left their spring host-plants and had migrated to the grapevines.

Copulation and Oviposition. *Erythroneura vulnerata* was not seen pairing at any time except on grapevines. The first matings observed in 1921 took place on May 8 and on May 10 in 1922. The mating period evidently was short because no copulating pairs were observed in the fields after June 5. The oviposition period extends over several weeks. In 1921, overwintering hoppers confined in cages at the insectary, deposited eggs from May 16 to July 10 and in 1922 from May 18 to July 17.

Young nymphs were found on leaves in the vineyard on May 31, 1921, and on May 24, 1922.

Number of Eggs Deposited. The eggs of this leafhopper are deposited beneath the epidermis of the leaf on the under surface or in the veins and petiole; in fact, it seemed to prefer the veins and petioles for places of egg deposition. The eggs were found with difficulty for this reason and in order to get a fairly accurate estimate of the number deposited, a few females were confined on grape leaves from the time of their mating until they died, and records were made of the nymphs that appeared. This method did not account for the eggs that did not hatch. A record of the number of nymphs produced by seven females is given in table 18.

Table 18—Nymphs Produced by Seven Overwintering Females
1921-1922

| 1 Female 6/10 | Nymphs Produced 18 | 1 Female 6/10 | Nymphs Produced 20 | 5 Female 6/19 | Nymphs Produced 95 |
|------------------|--------------------------|------------------|--------------------------|------------------|--------------------------|
| 6/20 | 31 | 6/20 | 26 | 6/30 | 105 |
| 6/30 | 29 | 6/30 | 22 | 7/7 | 120 |
| 7/15 | 15 | 7/15 | 18 | 7/22 | 80 |
| 7/27 | 9 | 7/25 | 7 | 8/2 | 40 |
| Total | 102 | | 93 | Total | 440 |

Longevity of Overwintering Adults. In order to determine the length of life of overwintering adults, a number of adults were caged upon grape leaves in the spring of 1921 and 1922. The cages were examined at short intervals when the number of dead were recorded and the remaining adults transferred to other vines at longer intervals so there would be no intermingling with newly transforming adults. In the first experiment, 83 adults were collected and confined in a cage on May 16 and three changes to new vines were made, the first on May 31, the second on June 21, and the third on July 8. In making transfer from one vine to another, 3 adults escaped on May 31, 5 on June 21 and 8 on July 8. Other records are given in table 19. For the second experiment, 45 adults were caged on grape leaves May 10 and were transferred to new vines on May 30, June 19 and July 7. Three adults escaped on June 19 and 5 on July 7. Other records are given in table 20. During the seasons of 1921

and 1922, overwintering adults lived on vines till nearly the end of July which was about three months from the time of the first appearance of the adults on the vines.

Table 19—Longevity of Overwintering Adults. 1921

| Date of Exam. | 5/31 | 6/2 | 6/4 | 6/10 | 6/14 | 6/18 | 6/21 | 6/24 | 6/30 | 7/5 | 7/8 | 7/11 | 7/15 | 7/18 | 7/21 | 7/28 |
|---------------|------|-----|-----|------|------|------|------|------|------|-----|-----|------|------|------|------|------|
| No. dead | 13 | 1 | 3 | 3 | 4 | 5 | 3 | 5 | 3 | 9 | 4 | 3 | 4 | 3 | 1 | 3 |

Table 20—Longevity of Overwintering Adults. 1922

| Date of Exam. | 5/30 | 6/5 | 6/10 | 6/13 | 6/19 | 6/23 | 6/27 | 6/30 | 7/7 | 7/10 | 7/14 | 7/18 | 7/21 | 7/25 | 7/27 |
|---------------|------|-----|------|------|------|------|------|------|-----|------|------|------|------|------|------|
| No. dead | 1 | 1 | 2 | 1 | 3 | 1 | 2 | 3 | 3 | 4 | 5 | 4 | 4 | 2 | 1 |

FIRST-BROOD ADULTS

Appearance and Maturity. The first adults from the spring brood nymphs appeared on June 14, 1921 and on June 10, 1922. By the last of June first-brood adults were appearing in considerable numbers and mating pairs were found, thus showing that the earliest of the first-brood adults had matured.

Copulation and Oviposition. The first appearing adults of this brood commenced mating the last of June and matings continued thru a period of several weeks. Adults of this brood that appeared on July 27, 1921, matured in part; the rest overwintered. First-brood adults deposited eggs from July 5 to September 6 in 1921 and from July 2 to September 8 in 1922.

SECOND-BROOD ADULTS

Appearance. The first adults appeared on August 3, 1921, and on July 30, 1922. A part at least of these early appearing adults matured and deposited eggs.

Oviposition. Twelve males and 11 females of this brood were placed on grape leaves on August 4, 1921. Eggs were deposited from August 25 to September 15, 1921. Adults of the second brood that appeared on September 1 did not deposit eggs. On August 1, 1922, 18 females and 20 males of the second-brood adults were placed on grape leaves and some of these commenced depositing eggs on August 22, the exact extent of the egg-laying

period was not determined, but there were still young nymphs with nearly mature nymphs on the leaves on October 17.

STAGES OF THE INSECT

The Egg

Description and Appearance. The eggs of this leafhopper are small objects about three-fourths of a millimeter long and about a third as wide. They are somewhat bean-shaped and slightly curved. The eggs are placed beneath the epidermis on the under side of the leaf or in the veins or petioles. It was frequently the case that the eggs could be found only in the petiole of the leaf. The eggs are very difficult to find without the use of a lens. In a bright light, they appear as slightly raised places on the under surface of the leaf.

Incubation Period. The incubation period was obtained by confining adults on grape leaves for periods of not over 24 hours and then making a record of each nymph as it appeared. In the life history studies of this leafhopper, the incubation period averaged 14.25 days for 112 complete rearings and the range was 11 to 17 days.

The Nymph

Hatching from the Egg. A few days before the eggs hatch, a dark spot may be plainly seen at one end of the egg. The spot represents the eye of the developing nymph, and it is at this end that the egg-covering is broken when the nymph comes out. The hatching process requires about twenty minutes. On several occasions, young nymphs were seen emerging from eggs in the petiole of the leaf. Here the young nymphs were standing out almost at right angles to the petiole. On one occasion, nymphs were seen emerging along the mid-vein on the upper surface of the leaf.

Nymphal Period. The nymph when it hatches from the egg is very light colored, with a slight tinge of brown on the sides of the body. The nymph molts five times and with each molt the brown color increases in intensity and extent, until just before the fifth molt, the entire nymph is brown except the under side of the thorax and legs. The average nymphal period for 112 rearings was 17.87 days; the range, 14 to 24 days.

Feeding Habits. The young nymphs begin feeding in a short time after emerging from the eggs. They are not very active and do not travel about to any great extent. The older nymphs get about more easily over the hairy surface of the leaves, are more active, and travel to some extent to other leaves that come in contact with the leaf on which they are living. Occasionally nymphs may be seen traveling on the petioles of the leaves. Probably the greater part of the nymphs feed on the same leaf thru their entire period of development. When the nymph is feeding, it sometimes requires considerable prodding with a needle point to induce it to withdraw its beak from the leaf. In the field, the nymphs feed on the under surface of the leaves, and in the laboratory when the leaves are laid flat in a dish, the nymphs almost invariably moved to the under side of the leaf regardless of which surface was down.

Adult

Description. The general color of *vulnerata* varies from brown to fulvous with a greenish tinge, and there are a number of pale spots and lines or markings. The anterior margin of the vertex is light colored and there is a light colored vitta bordering each eye. A more or less continuous pale median vitta or line extends over the vertex, pronotum and scutellum, and in addition there is a pale spot on the side of the pronotum. The clavus is marked with a whitish spot or streak on the inner margin at the base and a small spot beyond the middle, the corium with whitish streaks between sectors and a white spot near the posterior claval spot. The costal margin is whitish, interrupted by the oblique dark line and by a red one on the first cross-vein. The other cross-veins, sectors and apical veins are pale. The apex of the elytra is more or less smoky. Length of male 2.83 mm., length of female 2.88 mm.

Development

Length of Life Cycles. The leafhoppers that hatch from eggs laid in late summer or early fall hibernate over winter and return to the vines in early spring. There they mate after feeding for two or three weeks and then lay their eggs until about mid-summer. This gives a cycle of a little less than one year.

Hoppers that hatch from eggs laid in May and from the greater part of those laid in June begin laying after becoming mature five or six weeks later, and continue to lay eggs a month or two longer and then die. For these the life cycle is three or four months. In rearing experiments carried out in 1921, it was found that a part of the adults that came from eggs laid by overwintering hoppers on June 25 to June 30, matured and laid eggs the same season and a part lived over winter. It was also found that a part of the adults that came from second-brood eggs laid during the first few days of July matured and laid eggs the same season.

Number of Generations. There are two generations and a partial third a season, but for the season of 1921 at least some of the late appearing first-brood adults did not lay eggs that year, so that a full second generation was not completed. The mating periods for the broods varied considerably in extent. The overwintering adults began to mate the first week of May and continued to mate thru the first week of June. The first-brood adults commenced to mate the latter part of June and continued thru July, and thereafter an occasional mating pair was found up to the third week in August. These scattered matings in August represent matings of second-brood adults and matings of late appearing first-brood adults. At the insectary some of the second-brood adults matured and deposited eggs for a period of three or four weeks or to the middle of September. In the vineyard, there were still young and partially mature nymphs on October 16. For determining the number of broods the earliest appearing adults of the first and second broods were used.

Summary

Overwintering adults hibernate in trash, leaves, clumps of grass or weeds and in the late winter or early spring feed on plants nearby. They commence to appear on grape leaves the first of May or a little earlier or later according to the season and by the middle of May all have migrated to the grapevines. Some of these overwintering adults live on the vines till the last of July and lay eggs from the middle of May to about the middle of July. The first-brood nymphs were found in the field as early as May 24 in 1922 and the first-brood adults appeared on

June 14 in 1921 and June 10, 1922. First-brood adults laid eggs from about July 1 to the beginning of the second week of September. The second-brood adult appeared as early as August 3, in 1921 and July 30, 1921. A part of the second brood matured in 1921 and 1922 and laid eggs for a third brood.

Hoppers migrate from the vines about the middle of October. On October 16, 1922, in the evening, the hoppers were found collected in great numbers on the vines near a woodlot and by the next afternoon the greater part of these had left the vines. There were still a few hoppers and nymphs on the vines on October 24, but the leaves had practically all fallen off or were dried.

ERYTHRONEURA VULNERATA

RECORD OF REARINGS. 1920

Table 21—Second Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|--------------|--------------|--------------|--------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 15.43 | Days 3.24 | Days 3.00 | Days 3.13 | Days 3.43 | Days 6.05 | Days 18.25 | Days 34.27 | 16 | Males |
| Range | 13-17 | 2-5 | 2-5 | 2-5 | 2-5 | 4-7 | 16-22 | 31-37 | 21 | Females |

RECORD OF REARINGS. 1921

Table 22—First Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|-------------|--------------|-------------|-------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 14.5 | Days 3.9 | Days 2.75 | Days 2.4 | Days 2.6 | Days 3.45 | Days 15.1 | Days 29.6 | 9 | Males |
| Range | 14-16 | 3-5 | 2-4 | 2-3 | 2-4 | 3-4 | 14-17 | 27-32 | 11 | Females |

Table 23—Second Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|--------------|--------------|-------------|--------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 13.83 | Days 3.25 | Days 2.66 | Days 3.3 | Days 3.08 | Days 3.9 | Days 16.23 | Days 30.41 | 6 | Males |
| Range | 13-16 | 3-5 | 2-4 | 2-5 | 3-5 | 3-6 | 14-19 | 28-34 | 6 | Females |

Table 24—Third Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|--------------|--------------|--------------|--------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 13.8 | Days 3.68 | Days 3.64 | Days 3.23 | Days 3.38 | Days 5.07 | Days 19.07 | Days 32.98 | 7 | Males |
| Range | 13-16 | 3-5 | 3-4 | 3-4 | 3-4 | 4-7 | 16-24 | 29-37 | 6 | Females |

RECORD OF REARINGS. 1922

Table 25—Second Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|--------------|--------------|-------------|--------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 13.06 | Days 3.13 | Days 2.87 | Days 3.0 | Days 3.13 | Days 5.2 | Days 17.73 | Days 30.79 | 6 | Males |
| Range | 11-15 | 2-4 | 2-3 | 2-4 | 3-4 | 4-7 | 15-19 | 27-32 | 9 | Females |

Table 26—Third Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex | |
|--------------------------------|-----------------|-------------|-------------|--------------|--------------|-------------------|-------------------------------------|------------------|-----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 13.6 | Days 3.6 | Days 3.4 | Days 3.66 | Days 3.26 | Days 5.6 | Days 19.52 | Days 32.52 | 9 | Males |
| Range | 13-15 | 3-5 | 3-4 | 3-5 | 3-4 | 4-8 | 18-23 | 31-37 | 7 | Females |

EXPLANATION OF RECORD OF REARINGS

Table 21. These rearings were made from eggs deposited July 9 to July 16 by two females that were found copulating with males July 1. These females were reared from presumably first-brood nymphs which were collected in the vineyard on June 18. The adults represented by these rearings appeared August 10 to August 20.

Table 22. These rearings were made from eggs laid on May 16 to May 20 by overwintering adults. The adults from these eggs appeared on June 14 to June 19 and were first-brood adults.

Table 23. The twelve rearings recorded in this table were made from eggs laid on July 5 to July 8 by a single first-brood female. These second-brood adults appeared on August 3 to August 8.

Table 24. The eggs used for these rearings were laid on August 22 to August 25. The adults appeared on September 23 to October 7.

Table 25. The eggs for the rearings in this table were laid on July 2 to July 4 by two females that were seen to copulate with males on June 26. These two females were reared from nymphs collected in the vineyard on May 24. The adults from these rearings appeared on July 30 to August 5.

Table 26. Eggs for these rearings were secured by confining on grape leaves adults of the second brood that appeared on July 30 and August 1. The eggs were laid on August 22 to August 24, and the third-brood adults appeared on September 22 to September 30.

Erythroneura Sp.*

LIFE HISTORY AND HABITS

This leafhopper is found occasionally on grapevines and in general appearance is somewhat similar to *Erythroneura comes*. It breeds on the sycamore and was found breeding on no other plant. Attempts were made in 1920 to rear this leafhopper on grape leaves, using overwintering and first-brood adults, but very few eggs were deposited in the leaves and the nymphs died after the first molt. These eggs were deposited by first-brood

*The undersigned is responsible for including this insect with the grape-infesting leafhoppers to be studied by Mr. Jewett, the object being to determine whether or not it is related with those attacking cultivated grape. It is evident that it is not a variety of *Erythroneura comes*. It has always been very common on the leaves of sycamore in Kentucky and only by accident occurs on grape, where it does not breed. Specialists to whom examples were submitted have always persisted in calling it *E. comes*, tho it does not agree with Say's original description of that species. Professor Gillette, author of the name *E. maculata*, which he regarded as a variety of *E. comes*, has recently declared after an examination of material from Kentucky that it does not represent *E. maculata*. The sycamore infesting insect differs from *E. comes* in lacking the black dot in the second apical cell; in having a minute black dot well within the costal margin near the middle of the wing, where *E. comes* has a conspicuous oblique black dash; and in the second and third sectors continuing with little interruption thru the cross veins, thence to the tip of the wing; in the base of the fourth apical cell being oblique instead of forming a right angle with the inner edge of the wing.—H. Garman.

adults that appeared on July 20, 1920. The adults had been kept on sycamore leaves from July 20 to August 4th, and were then transferred to grape leaves where they remained until August 23. Both overwintering and first-brood adults were kept alive on grape leaves for several weeks.

OVERWINTERING ADULTS

Hibernation. The leafhoppers hibernate among leaves or trash near the host-plant, directly under the tree or along hedge rows or around clumps of shrubbery nearby. They apparently do not need a great deal of protection since they were frequently found under a slight covering of leaves.

Activity in Early Spring. In the early spring, the hoppers become more or less active and evidently get food from succulent plants near their hibernating quarters. They were found in grass, on plantain, dandelion and clover and later an occasional specimen was found on privet, honeysuckle and spirea. The hoppers were found in considerable numbers on the trees by June 1, in 1920, and they were appearing on the trees May 15 in 1921. The hoppers evidently do not migrate far from their hibernating quarters because some trees in the neighborhood would be free from the insect the entire season.

Copulation and Oviposition. This leafhopper was not found mating on any plant except sycamore. In 1920, the first mating pairs were found on June 1 and in 1921 on May 20. The mating period is short. It lasted until about the middle of June in 1920 and until about the 10th of June in 1921. Eggs were deposited by females confined in cages from June 8 to July 12 in 1920, and from May 24 to July 17 in 1921. These egg-laying periods are comparatively short and it is probable that eggs were laid later in the season by overwintering adults outside of cages.

Number of Eggs Deposited. The eggs are placed under the epidermis on the under surface of the leaf and are difficult to find. The approximate number laid was obtained by confining adults on leaves and counting the nymphs that hatched. A single female which mated June 1, 1920, produced 68 nymphs; this female died on July 20. Four females which mated June 2, 1920, produced 234 nymphs. The last nymph hatched July 24. Two of the females died July 10-12 and two on July 19-22. On May

16, 1921, three females which were caught just after mating were caged on sycamore leaves. The first nymphs hatched on June 7 and the last on July 20, there being 307 nymphs in all.

Longevity of Overwintering Adults. Overwintering adults which were confined upon leaves in cheesecloth bags lived for several weeks. On June 6, 1920, 32 hoppers were caged on leaves in order to determine how long they would live. The bags were removed at about weekly intervals and the number of hoppers counted. Shorter intervals between transfers were not made, principally because it was almost impossible to prevent the escape of some of the hoppers. The record of the 32 hoppers is as follows: 1 dead and 1 escaped June 13; 4 dead June 16; 2 dead and 3 escaped June 30; 4 dead July 5; 9 dead and 2 escaped July 11; 3 dead July 20; 3 dead July 27. The experiment was repeated in 1921 by caging 60 leafhoppers on May 24. The record of these is as follows: 8 escaped June 1; 2 dead June 13; 14 dead July 4; 6 dead July 14; 16 dead July 20 and 4 escaped; 8 dead August 8; 2 dead August 17.

FIRST-BROOD ADULTS

Appearance and Maturity. During the season of 1920, first-brood adults began to appear July 9 but they were not numerous until July 15. In 1921, first-brood adults appeared as early as June 22, which was about two weeks earlier than the first-brood adults appeared in 1920. Adults of this brood were numerous the last week of June in 1921. Matings were observed July 20, 1920 and July 1, 1921, which indicated that a part at least of the adults had matured.

Copulation and Oviposition. Copulating pairs were found on the leaves from July 20 to August 8 in the season of 1920, but very few matings were observed after July. In 1921, copulating pairs were found thru July and an occasional pair the first week of August. Eggs were laid from the first of August thru the first week of September in 1920. First-brood adults in a bag commenced to lay eggs on July 12, 1921, and continued to lay eggs thru the first few days of September. These adults were transferred to new leaves on August 31 and again on September 13, and from the leaves on which the adults had been confined from August 31 to September 13, a few just hatched nymphs were collected September 20.

SECOND-BROOD ADULTS

Appearance. During the season of 1920, the earliest second-brood adults appeared on September 3 and latest on October 10. Seventy-five adults of this brood that appeared on September 3 to September 20 failed to produce nymphs. The leaves upon which these adults had been confined were examined carefully for the last time on October 18 when no eggs or nymphs were found.

Adults of this brood began to appear on August 8, 1921. This was a little more than three weeks earlier than the first appearance of second-brood adults in 1920. On August 8 to August 10, 18 males and 27 females of this brood were caged on leaves to see if they would produce nymphs. Careful examinations of the leaves were made August 25, September 10, September 21, and on October 6 and October 19, but there were no nymphs on the leaves on any of these dates. Nymphs were found on the trees, however, as late as October 14, but these evidently were late maturing nymphs of the second brood. The nymphs at that date were practically all mature and ready to transform into adults.

STAGES OF THE INSECT**The Egg**

Description and Appearance. The eggs of this *Erythron-eura* are about three-fourth of a millimeter long by about one-third as wide. They are slightly curved and are shaped somewhat like a kidney bean. They are transparent when freshly laid and are very delicate and difficult to dissect from the tissue in which they are placed. The eggs are placed beneath the epidermis on the under side of the leaf and appear as slightly raised places on the surface of the leaf. They are deposited singly over the surface of the leaf along the ribs or veins or between the veins.

Incubation Period. The egg period was obtained by confining adults on leaves for periods of not over 24 hours, and then recording the hatching dates of the nymphs. During the season of 1920, the average incubation period for 46 first-brood eggs was 14.93 days with a range of 13 to 18 days. The average incubation period for 23 first-brood eggs in 1921 was 13.78 days; the

range, 13 to 14 days. The average incubation period for 24 second-brood eggs in 1920 was 15.6 days and the range 15 to 17 days. The same period, for 26 second-brood eggs in 1921, was 13.5 days; the range, 12 to 14 days.

The Nymph

Description. The young sycamore leafhopper, when it hatches from the egg, is a very small, semi-transparent, pale yellowish nymph with large red or brownish eyes. The eyes lose some of their red color after the first stage and the yellowish color of the body becomes more pronounced. The nymph molts five times and after the last molt the adult appears. During the five stages of development, the most conspicuous change in the nymph is in the growth of the wing pads. These wing pads begin to appear as small lateral projections during the second stage and there is a gradual increase in size until the fifth stage when the pads reach about the middle of the fourth abdominal segment. The body of the nymph is covered with rather stiff bristles and a part of these are set in dusky spots. In the final stage, there are two slightly dusky spots on the pronotum, ten darker spots on the meso and metanotum and five on each side on the wing pads. Two of the bristles on the mesonotum and two on the metanotum are dusky colored. There are four rows of bristles on the abdomen.

Nymphal Period. The average nymphal period for the first-brood in 1920 was 16 days and for the same brood, in 1921, a little less than 16 days. The average nymphal period for the second-brood was about 19.5 days in 1920 and 16 days in 1921. The minimum nymphal period in 119 rearings was 14 days and the maximum 22 days.

Adult

Description. The color of this insect is yellowish with the following red or scarlet markings: Two median spots on the vertex often united posteriorly, sometimes a spot on the apex and orbits of the eyes; a discal spot, generally v-shaped, and two lateral spots on the pronotum; two or three spots on the clavus; basal angles and apex of scutellum; an oblique streak on the front of the costal plaque and a spot between this streak and clavus, the two sometimes united; three streaks posteriorly along

the sectors; a line on the cross-veins, extending somewhat on the adjacent parts of sectors and apical veins. The apical cells are yellowish fumose and there is a dark spot at the base of the fourth cell; occasionally, a minute dark spot on the costal margin. Length of male 2.78 mm., length of female 2.91 mm.

There is a consideratble variation in the extent and intensity of color markings. Some of the specimens have the markings broken into spots with color more of orange than red. The markings of the head and pronotum are very faint in many of the specimens.

Development

Length of Life Cycles. The leafhoppers that hatch from eggs laid in late summer hibernate overwinter near the host-plant and return to the sycamore at about the middle of May of the following spring. Here they mate and lay their eggs from about the first of June to the middle of July, and accordingly, they have a life cycle of about one year. Overwintering adults kept in bags on sycamore leaves practically all died by the last week of July or the first week of August. The hoppers that hatch from eggs laid from the last of May thru June mature in about six weeks, and lay eggs for a month or two and die. For these, the life cycle is three or four months.

Number of Generations. During the seasons of 1920 and 1921, when careful rearings were made of this leafhopper, it was found that there was one and a partial second brood. There were two active mating periods during each season which would indicate but two broods. In 1921, second-brood adults appeared as early as August 8, but these failed to produce nymphs.

In order to find out how late in the season first-brood adults would mature and produce young, first-brood adults reared from eggs known to have been laid at definite times were used. In 1920, 25 first-brood adults which emerged July 27 to August 8 from eggs deposited June 25 to June 30 were caged on leaves. Young nymphs were found on the leaves August 30. The adults were moved to other leaves August 30, September 13 and October 9. None of the adults were alive October 14. No nymphs appeared in the bag in which the adults were confined from September 13 to October 9. In the bag that contained the adults

from August 30 to September 13, there were young and nearly mature nymphs September 28. In another experiment, first-brood adults which appeared August 6 to August 12 from eggs deposited June 30 to July 2, did not produce nymphs that season.

Summary

The sycamore leafhoppers hibernate in leaves or trash and in the spring return to the sycamore where they mate and begin laying eggs in the last week of May or the first week of June. These overwintering adults lay eggs until about the middle of July, some of them living until after the first week in August. First-brood adults appeared on July 9, 1920, on June 22, 1921, and on June 20, 1922. First-brood adults in bags laid eggs from the first week in August thru the first week of September, 1920, and from July 12, 1921, thru the first few days of September. During the seasons of 1920 and 1921, two broods developed, but the second brood was not a full brood. First-brood adults that appeared after August 8, 1920, did not lay eggs that season and in 1921, second-brood adults that appeared on August 8 to August 10 did not produce another brood. Second-brood adults appeared about three weeks earlier in 1921 than in 1920.

The hoppers that appear in late summer or early fall leave the trees to seek hibernating quarters at about the middle of October. They apparently do not migrate to any great distance either in the fall or spring, since trees within relatively short distances from infested trees, were free from the hoppers for the two seasons during which the observations were being made.

RECORD OF REARINGS. 1920.

Table 27—First Brood—*Erythroneura* sp.

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. Number Reared | Sex | | |
|--------------------------------|-----------------|--------------|--------------|--------------|--------------|-------------------|---|---------------|----|---------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | | |
| Average | Days 14.93 | Days 3.37 | Days 3.06 | Days 2.53 | Days 3.08 | Days 4.02 | Days 16.00 | Days 30.98 | 20 | Males |
| Range | 13-18 | 2-5 | 2-4 | 1-5 | 2-5 | 2-6 | 14-19 | 29-36 | 26 | Females |

Table 28—Second Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex |
|--------------------------|-----------------|-----------|-----------|-----------|-----------|----------------|-------------------------------|---------------|------------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | |
| Average | Days 15.60 | Days 4.22 | Days 3.61 | Days 3.00 | Days 3.44 | Days 5.38 | Days 19.66 | Days 35.28 | 10 Males |
| Range | 15-17 | 4-5 | 2-6 | 2-5 | 2-5 | 4-7 | 17-22 | 34-37 | 14 Females |

RECORD OF REARINGS. 1921.

Table 29—First Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex |
|--------------------------|-----------------|-----------|-----------|----------|-----------|----------------|-------------------------------|---------------|------------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | |
| Average | Days 13.78 | Days 3.85 | Days 2.78 | Days 2.5 | Days 2.13 | Days 4.21 | Days 15.57 | Days 29.36 | 10 Males |
| Range | 13-14 | 3-5 | 2-3 | 2-4 | 2-3 | 4-5 | 15-17 | 29-30 | 13 Females |

Table 30—Second Brood

| Incubation Period of Egg | Nymphal Instars | | | | | Nymphal Period | Combined Egg and Nymphal per. | Number Reared | Sex |
|--------------------------|-----------------|-----------|-----------|-----------|-----------|----------------|-------------------------------|---------------|------------|
| | 1st | 2nd | 3rd | 4th | 5th | | | | |
| Average | Days 13.50 | Days 3.75 | Days 2.18 | Days 2.25 | Days 3.13 | Days 4.68 | Days 16.01 | Days 29.56 | 12 Males |
| Range | 12-14 | 3-5 | 2-4 | 2-4 | 2-4 | 4-6 | 15-19 | 29-32 | 14 Females |

Explanations of Tables of Rearings

Table 27. The eggs for the rearings represented in this table were laid on June 16 to June 24, and the adults appeared July 16 to July 25. The table is a summary of 46 complete rearings.

Table 28. The eggs for the rearings represented in this table were laid August 4 and August 16 and 17. Adults appeared September 7 to September 10 from the eggs laid on August 4 and on September 19 to September 23 for eggs laid August 16 and August 17.

Table 29. The eggs for the rearings represented by this table were laid on May 27 to May 31. The adults appeared June 25 to June 30, there being 23 complete rearings.

Table 30. The eggs for the rearings represented in this table were laid on July 12 to July 15. The adults appeared from August 8 to August 15.

TEMPERATURE RECORDS FROM U. S. WEATHER BUREAU
REPORT

| Date 1920 | May | | June | | July | | August | | September | | October | |
|--------------|------|------|------|------|------|------|--------|------|-----------|------|---------|------|
| | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| 1 | 63 | 40 | 73 | 65 | 88 | 69 | 75 | 59 | 76 | 62 | 52 | 40 |
| 2 | 58 | 48 | 83 | 64 | 80 | 69 | 72 | 55 | 67 | 58 | 63 | 40 |
| 3 | 60 | 40 | 71 | 62 | 90 | 70 | 79 | 54 | 74 | 52 | 72 | 48 |
| 4 | 64 | 43 | 62 | 56 | 81 | 65 | 88 | 62 | 73 | 60 | 78 | 56 |
| 5 | 67 | 49 | 69 | 54 | 86 | 60 | 88 | 70 | 75 | 63 | 66 | 50 |
| 6 | 71 | 48 | 69 | 52 | 83 | 68 | 87 | 65 | 77 | 62 | 56 | 42 |
| 7 | 63 | 50 | 77 | 55 | 78 | 66 | 84 | 63 | 79 | 62 | 64 | 44 |
| 8 | 69 | 46 | 81 | 63 | 82 | 62 | 78 | 66 | 74 | 65 | 71 | 49 |
| 9 | 72 | 54 | 87 | 67 | 79 | 62 | 78 | 63 | 76 | 64 | 76 | 56 |
| 10 | 75 | 58 | 88 | 72 | 77 | 65 | 79 | 66 | 78 | 63 | 78 | 57 |
| 11 | 77 | 60 | 89 | 73 | 77 | 63 | 85 | 69 | 84 | 67 | 79 | 57 |
| 12 | 74 | 59 | 88 | 73 | 84 | 66 | 81 | 67 | 79 | 62 | 79 | 58 |
| 13 | 59 | 46 | 89 | 69 | 87 | 70 | 80 | 69 | 79 | 65 | 82 | 58 |
| 14 | 53 | 38 | 89 | 68 | 83 | 67 | 82 | 69 | 84 | 66 | 80 | 61 |
| 15 | 61 | 42 | 92 | 72 | 83 | 68 | 78 | 68 | 79 | 65 | 78 | 62 |
| 16 | 75 | 44 | 89 | 72 | 84 | 69 | 80 | 67 | 79 | 62 | 78 | 62 |
| 17 | 62 | 55 | 76 | 59 | 86 | 69 | 82 | 66 | 73 | 55 | 78 | 58 |
| 18 | 64 | 55 | 72 | 53 | 82 | 68 | 82 | 68 | 79 | 57 | 82 | 61 |
| 19 | 73 | 57 | 66 | 56 | 77 | 64 | 84 | 68 | 81 | 65 | 78 | 64 |
| 20 | 70 | 64 | 68 | 56 | 79 | 62 | 87 | 70 | 86 | 63 | 82 | 64 |
| 21 | 75 | 62 | 68 | 55 | 84 | 64 | 81 | 67 | 88 | 68 | 83 | 65 |
| 22 | 78 | 61 | 73 | 57 | 88 | 69 | 70 | 59 | 86 | 67 | 84 | 63 |
| 23 | 85 | 64 | 76 | 56 | 93 | 71 | 67 | 53 | 85 | 63 | 83 | 63 |
| 24 | 78 | 66 | 82 | 63 | 93 | 70 | 74 | 57 | 81 | 67 | 76 | 64 |
| 25 | 74 | 62 | 80 | 62 | 76 | 59 | 77 | 60 | 87 | 68 | 70 | 61 |
| 26 | 77 | 60 | 83 | 62 | 73 | 53 | 81 | 62 | 85 | 70 | 69 | 60 |
| 27 | 82 | 63 | 90 | 67 | 77 | 56 | 82 | 63 | 82 | 64 | 47 | 34 |
| 28 | 83 | 62 | 89 | 70 | 83 | 62 | 81 | 63 | 76 | 62 | 41 | 30 |
| 29 | 76 | 55 | 87 | 71 | 88 | 70 | 74 | 68 | 66 | 45 | 54 | 33 |
| 30 | 87 | 60 | 82 | 67 | 90 | 67 | 83 | 67 | 50 | 44 | 60 | 43 |
| 31 | 77 | 62 | | | 89 | 67 | 82 | 66 | | | | |

**TEMPERATURE RECORDS FROM U. S. WEATHER BUREAU
REPORT**

| Date | May | | June | | July | | August | | September | | October | |
|------|------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | 1921 | Max. Min. |
| 1 | 58 | 39 | 88 | 64 | 90 | 71 | 90 | 65 | 86 | 70 | 71 | 53 |
| 2 | 46 | 41 | 91 | 66 | 94 | 74 | 92 | 73 | 83 | 71 | 75 | 54 |
| 3 | 45 | 40 | 88 | 68 | 95 | 76 | 77 | 68 | 86 | 71 | 63 | 48 |
| 4 | 62 | 44 | 73 | 57 | 95 | 77 | 83 | 63 | 77 | 63 | 55 | 40 |
| 5 | 65 | 47 | 75 | 50 | 95 | 74 | 87 | 66 | 86 | 69 | 60 | 42 |
| 6 | 66 | 44 | 82 | 56 | 96 | 76 | 86 | 70 | 80 | 68 | 70 | 47 |
| 7 | 67 | 46 | 88 | 61 | 94 | 73 | 77 | 63 | 80 | 65 | 71 | 39 |
| 8 | 72 | 55 | 75 | 63 | 91 | 73 | 79 | 60 | 85 | 69 | 48 | 36 |
| 9 | 75 | 53 | 78 | 67 | 85 | 71 | 82 | 63 | 82 | 68 | 68 | 39 |
| 10 | 67 | 58 | 85 | 67 | 89 | 69 | 87 | 64 | 84 | 67 | 69 | 55 |
| 11 | 71 | 58 | 77 | 69 | 89 | 71 | 84 | 68 | 84 | 67 | 55 | 42 |
| 12 | 73 | 57 | 84 | 67 | 88 | 68 | 84 | 70 | 82 | 67 | 48 | 36 |
| 13 | 75 | 58 | 90 | 70 | 86 | 69 | 85 | 67 | 83 | 65 | 58 | 41 |
| 14 | 69 | 51 | 89 | 67 | 86 | 71 | 74 | 61 | 85 | 67 | 68 | 43 |
| 15 | 64 | 50 | 87 | 63 | 88 | 70 | 75 | 55 | 84 | 70 | 70 | 49 |
| 16 | 62 | 45 | 90 | 65 | 88 | 67 | 77 | 57 | 89 | 64 | 72 | 54 |
| 17 | 74 | 44 | 90 | 71 | 91 | 71 | 86 | 71 | 90 | 71 | 78 | 58 |
| 18 | 80 | 60 | 90 | 67 | 94 | 72 | 83 | 70 | 76 | 62 | 68 | 55 |
| 19 | 85 | 61 | 80 | 69 | 90 | 74 | 87 | 69 | 82 | 53 | 69 | 46 |
| 20 | 83 | 67 | 89 | 67 | 85 | 71 | 91 | 68 | 87 | 69 | 50 | 44 |
| 21 | 81 | 64 | 84 | 69 | 85 | 64 | 78 | 63 | 81 | 62 | 59 | 39 |
| 22 | 83 | 62 | 87 | 69 | 88 | 64 | 76 | 58 | 78 | 58 | 69 | 44 |
| 23 | 86 | 67 | 88 | 72 | 90 | 67 | 79 | 62 | 81 | 65 | 76 | 53 |
| 24 | 87 | 66 | 90 | 69 | 89 | 70 | 86 | 66 | 74 | 67 | 78 | 57 |
| 25 | 82 | 68 | 91 | 69 | 86 | 70 | 86 | 66 | 73 | 53 | 77 | 53 |
| 26 | 79 | 65 | 92 | 74 | 87 | 69 | 86 | 66 | 63 | 55 | 77 | 49 |
| 27 | 85 | 68 | 90 | 75 | 91 | 69 | 82 | 66 | 78 | 63 | 62 | 52 |
| 28 | 84 | 69 | 85 | 68 | 91 | 71 | 87 | 66 | 80 | 62 | 70 | 53 |
| 29 | 80 | 66 | 86 | 71 | 89 | 70 | 88 | 71 | 82 | 66 | 71 | 52 |
| 30 | 84 | 64 | 90 | 71 | 91 | 71 | 88 | 71 | 74 | 53 | 66 | 52 |
| 31 | 87 | 67 | | | 88 | 70 | 87 | 71 | | 58 | 51 | |

**TEMPERATURE RECORDS FROM THE EXPERIMENT STATION
REPORT**

| Date | May | | June | | July | | August | | September | | October | |
|------|------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | 1922 | Max. Min. |
| 1 | 76 | 48 | 74 | 62 | 90 | 74 | 85 | 68 | 88 | 70 | 83 | 60 |
| 2 | 74 | 59 | 69 | 63 | 85 | 72 | 81 | 65 | 90 | 72 | 84 | 59 |
| 3 | 65 | 61 | 78 | 60 | 70 | 65 | 84 | 67 | 82 | 70 | 85 | 60 |
| 4 | 75 | 60 | 79 | 65 | 72 | 60 | 85 | 64 | 87 | 73 | 88 | 61 |
| 5 | 75 | 55 | 83 | 64 | 78 | 55 | 87 | 68 | 89 | 71 | 85 | 61 |
| 6 | 69 | 53 | 81 | 65 | 81 | 58 | 91 | 68 | 90 | 70 | 79 | 65 |
| 7 | 72 | 55 | 85 | 65 | 84 | 56 | 88 | 73 | 90 | 70 | 75 | 65 |
| 8 | 78 | 50 | 82 | 70 | 81 | 70 | 80 | 64 | 91 | 72 | 60 | 55 |
| 9 | 84 | 56 | 77 | 70 | 86 | 70 | 80 | 59 | 88 | 70 | 60 | 57 |
| 10 | 84 | 61 | 84 | 67 | 89 | 72 | 78 | 58 | 87 | 72 | 63 | 53 |
| 11 | 81 | 66 | 84 | 69 | 87 | 72 | 84 | 60 | 72 | 61 | 59 | 57 |
| 12 | 82 | 68 | 84 | 67 | 90 | 73 | 84 | 67 | 75 | 60 | 60 | 45 |
| 13 | 77 | 57 | 84 | 64 | 84 | 70 | 80 | 70 | 81 | 56 | 63 | 40 |
| 14 | 75 | 55 | 86 | 69 | 83 | 66 | 91 | 68 | 84 | 63 | 72 | 50 |
| 15 | 76 | 54 | 86 | 69 | 87 | 66 | 92 | 69 | 86 | 65 | 75 | 55 |
| 16 | 80 | 60 | 90 | 70 | 87 | 68 | 92 | 70 | 78 | 64 | 70 | 60 |
| 17 | 72 | 62 | 92 | 72 | 90 | 71 | 91 | 70 | 73 | 60 | 62 | 40 |
| 18 | 70 | 57 | 83 | 70 | 82 | 71 | 92 | 72 | 79 | 53 | 58 | 36 |
| 19 | 67 | 56 | 84 | 66 | 82 | 65 | 88 | 71 | 80 | 64 | 65 | 36 |
| 20 | 74 | 54 | 81 | 71 | 83 | 64 | 82 | 65 | 71 | 63 | 68 | 40 |
| 21 | 80 | 56 | 84 | 61 | 86 | 63 | 84 | 62 | 78 | 63 | 68 | 51 |
| 22 | 82 | 62 | 80 | 62 | 90 | 67 | 88 | 72 | 84 | 62 | 74 | 53 |
| 23 | 86 | 66 | 84 | 60 | 87 | 72 | 82 | 68 | 85 | 60 | 63 | 41 |
| 24 | 82 | 65 | 85 | 59 | 87 | 72 | 83 | 72 | 83 | 65 | 58 | 37 |
| 25 | 77 | 67 | 89 | 65 | 89 | 71 | 84 | 71 | 70 | 53 | 66 | 44 |
| 26 | 76 | 67 | 87 | 69 | 91 | 71 | 81 | 63 | 74 | 60 | 61 | 41 |
| 27 | 77 | 63 | 90 | 70 | 92 | 72 | 79 | 61 | 76 | 63 | 70 | 40 |
| 28 | 76 | 61 | 83 | 70 | 92 | 73 | 82 | 67 | 80 | 63 | 77 | 48 |
| 29 | 78 | 57 | 87 | 69 | 88 | 66 | 85 | 62 | 88 | 60 | 80 | 50 |
| 30 | 82 | 56 | 89 | 74 | 89 | 69 | 82 | 68 | 83 | 59 | 80 | 53 |
| 31 | 86 | 63 | | | 87 | 71 | 85 | 69 | 75 | 59 | 50 | |

SUGGESTIONS FOR CONTROL

Sprays to be effective must be applied when the insect is in the nymph stage and when the nymphs become numerous on the vines. The nymphs appear in greatest numbers at about the middle of July to the first of August.

The nymphs are sensitive to nicotine sprays and may be killed by a solution of nicotine sulfate, at a dilution of 1 part of the commercial 40 per cent nicotine sulfate to 1,400 parts of water. The solution is made by mixing one pint of the nicotine sulfate with 175 gallons of water. A dilution of one pint of nicotine sulfate to 200 gallons of water is nearly as effective as the stronger solution and may be applied with good results when the nymphs are not too far developed. The 1 to 1,400 solution killed 97 to 100 per cent of the nymphs of various sizes and the 1 to 1,600 killed 96.5 to 100 per cent of the nymphs of various sizes.

The nicotine sulfate may be applied as a single solution or it may be mixed with Bordeaux mixture at the time this spray is being applied for fungus diseases. It is necessary to direct the spray against the under side of the leaves in order to hit the nymphs because they live on that side of the leaves.

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